In bringing my remarks to a close I hope that their main intent, despite their rambling and somewhat desultory character, may have become plain to you. I have tried to show you that medical laboratories such as these are indispensable in medical schools which are at all worthy of being known as the medical departments of true universities, and I have maintained that only in such laboratories can students be properly taught, for they come there into direct personal contact with the objects of study, a requisite if the scientific habit of thought is to be engendered. To them, too, your physicians and your guardians of the community's health may resort for making the special laboratory examinations now necessary for the diagnosis, the cure and the prevention of the ills by which your people are afflicted. And, above all, opening off these halls there are some rooms which will, I trust, become the workshops of mature original investigators and others which will serve as nurseries in which will be cultivated those qualities of mind, heart and hand which make men dissatisfied with knowledge as it is and compel them to try to extend it.

Untrammeled by the traditions and ultra-conservatism which are holding medicine back in the mother country, yet protected by intimate connection with her from the whimsical vagaries, the wildness and the freakishness which might otherwise tend to bring medical science here into disrepute, Canadians have an opportunity and a privilege in medicine they will not be slow to take advantage of, a duty they are sure manfully to assume. There are many young men and women in this country and this province capable of devotion to an ideal cause, independent of personal gain and glory. It is to the credit of Canadian parents that they instil into their children high and noble aspirations, that they teach them to endure privations cheerfully for the sake of things greater than mere physical comforts, and that they cultivate that generosity and elevation of spirit which make unselfish human effort not only possible, but really desirable. The fruits of this training will, I dare prophesy, become evident sooner or later in the activities of these laboratories. In them there will be professors and students who will choose as their life work the pursuit of medical truth and the acquisition of medical knowledge for its own sake; as a result of this ennobling and worthy occupation human suffering will be ameliorated, and, perhaps, some patients suffering from maladies now incurable may be healed. May the high aims and purposes of those who have planned these buildings and made their erection possible be realized! May the good that you hope for be the outcome of work in the laboratories which with suitable solemnity and earnest purpose you have set apart and consecrated to a special service to-day!

LEWELLYS F. BARKER
THE JOHNS HOPKINS UNIVERSITY

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
SECTION B—PHYSICS

II

A Relation of Mass to Energy: DANIEL F. COMSTOCK, Ph.D. (Read by title.)

In the paper of which this is an abstract it is shown that the momentum of any purely electric system having any internal motions and constraints, but possessing on the whole a kind of average symmetry, is given by the expression

$$M = \frac{2W^T v}{V^2[1 + (v/V)^2]}.$$

Here M is the momentum of the system, (v) its velocity as a whole, V the velocity of light and W^T the part of the total electromagnetic energy which is represented

by the components of the electric and magnetic forces which lie perpendicular to the direction of motion of the system. This is a highly general result and is obtained by a method involving the generalized constraints of the system.

When the second order of the ratio v/V may be neglected, W_T is equal to two thirds the total electromagnetic energy (W) of the system (because of the average symmetry before mentioned), and hence we have

$$\text{Mass} = 4/3\ 1/V^2\ W.$$

This gives the electromagnetic mass of the system in terms of its total energy content.

If the electrical theory of matter be accepted this result applies to the mass of any piece of matter and we have the mass proportional to the total contained energy.

It is shown that if this hypothesis is accepted the irregularities which exist in the table of atomic weights are in harmony with the evolutionary theory of the elements.

Also on this basis gravitation must be considered as acting between quantities of confined energy and not between masses in any other sense.

Method of Determining the Modulus of Bending of a Flat Spring: R. S. Woodward, Carnegie Institution of Washington. (Read by title.)

The method applies especially to a uniform flat spring held rigidly and horizontally at one end but otherwise free to assume the shape due to its weight. The exact theory of this shape shows that measurements (1) of the vertical sag of the spring at any point of its length, (2) of its weight per unit length, and (3) the total length of its free part will give the modulus of bending.

An Investigation of the Optical Properties of Films of Magnetic Metals: C. A. Skinner and A. Q. Tool, University of Nebraska.

This paper deals with the magnetic rotation and ellipticity produced by films of iron, cobalt and nickel of definite thicknesses together with the refractive indices, reflection and transmission of the same.

It appears that two distinct types of films may be produced by cathode deposit *in vacuo*, one a *metallic* the other a *dark* film. The difference does not arise from the gas in which the films are produced, for they are alike, whether hydrogen, nitrogen or helium be used as gas filling.

The optical properties of these different types are quite different, and they also differ from those obtained by electrolytic deposition. Both iron and cobalt in the *metallic* type possess magnetic rotary power four times as large as the electrolytic films, while the *dark* types exhibit a rotary power remarkably smaller than the electrolytic. The ellipticity imparted to the transmitted ray is affected to an equal degree.

Dark films of iron have an absorption region in the blue and in this region the magnetic rotation and ellipticity reverse their directions, as might be predicted from the characteristics exhibited by other substances possessing an absorption region in the visible spectrum. *Dark* films of cobalt show also interesting results in the visible spectrum, which duplicate in a sense the results from the iron.

Only *metallic* films of nickel could be obtained and these exhibited effects almost too small to measure.

The Electric Double Refraction of Carbon Bisulphide: Charles F. Hagenow, Armour Institute.

In insulating media subjected to an electric field, light waves vibrating in the direction of the field are propagated at a veloc-

ity different from those vibrating perpendicular to it. Kerr's law for the relative retardation of two such vibrations is given by the formula

$$\delta = B\ V^2 l/d^2$$

where V is the difference of potential between the two parallel plates of a plane condenser producing the field, d their distance apart, and l the length of path of the ray in the field. B is thus the constant of the dielectric used.

For different reasons it is important to determine this constant for carbon bisulphide. Previous investigators have found it to fluctuate over a range as high as twenty per cent. This paper deals with the treatment of the liquid necessary to reproduce results, and finally gives a series of careful determinations of B for various wave-lengths. Incidentally the results of Blackwell, showing that Kerr's law for the variation of the retardation with the wave-length is in error, are supported.

The Spectrum of Calcium: JAMES BARNES, Bryn Mawr College. (Read by title.)

The paper considers the changes produced in the intensity and distribution of light in the lines of the calcium spectrum obtained from an arc between metallic electrodes in air at atmospheric pressure and at lower pressures with varying current-strength. The results can be explained as a density effect rather than a temperature one.

The new triplets found by Saunders in a copper arc moistened with $CaCl_2$ appear very clearly and sharp when the arc is produced in a vacuum with a current of 12 amperes.

Many attempts were made to obtain true double reversals of the H and K lines with a steady arc, but without success. False multiple and double reversals appear in some of the other lines.

Upon the Magnetic Separation of the Spectral Lines of Barium, Yttrium, Zirconium and Osmium: B. E. MOORE, University of Nebraska.

Preston observed a similarity in the magnetic separation for spectral lines which formed similar series. Runge and Paschen confirmed this observation for a number of substances.

This research uses the magnetic separation of spectrum lines to search for series in cases where they have not been before observed. Runge used this method with barium.

The substances were volatilized by means of a spark in a strong magnetic field (24,400 c.g.s. units per sq. cm.) and photographed by means of a 21-foot grating. The components were separated by a calcite prism. Observations were made upon barium, yttrium, zirconium and osmium. A table was presented, showing an extended comparison between the author's results and some recently published by Runge.

The most prominent feature of the table is the fact that most of the lines of the substances here studied do not belong to the types which are represented in the well-known series groups. The next prominent feature is that the types are seldom duplicated. Thirdly, a great many types have common intervals, whose difference consists in a variety of the factors by which the interval must be multiplied to produce the actual separation. Fourthly, whether or not the intervals are aliquot parts of a normal interval a is not so decisive. It can easily be contended that the intervals are irrational fractions.

Fifthly, the Zeemann triplets offer no great advantages for the study of series unless the magnitudes of the separations separate into well-defined groups, as they do not in zirconium, osmium and yttrium.

Sixthly, series are eliminated from the

lines having several components except under quadruplets of zircon designated by interval $3a/8$. No series was found here.

An extended abstract of this investigation may be found in the *Physical Review.*

On the Absorption of Short Electric Waves by Air at Different Pressures: James E. Ives and R. E. Clyde Gowdy.

It has been known for some time that wireless telegraph messages can be sent farther at night than in the day. One explanation is that sunlight ionizes the air and this increases absorption.

To investigate this in the laboratory short electric waves were used, and were sent through a glass chamber in which the pressure could be varied. The waves were excited by a Righi oscillator 5 cm. long and received upon a thermo-junction made of fine iron and constantan wires. The intervening chamber was 44.5 cm. long, with plate-glass ends. Pressures were used ranging from .5 mm. of mercury up to 1 atmosphere. Two maxima of absorption and one minimum were found. One of the maxima is near zero pressure, the other between 40 and 60 cm. of mercury. The minimum lies between 25 and 35 cm. of mercury. The percentage absorption is not large, varying between $+7$ per cent. and -7 per cent. for the whole tube, or between $+.15$ per cent. and $-.15$ per cent. for each centimeter of its length.

The Magnetic Properties of Antimony: Arthur L. Foley, Indiana University.

Antimony can be made to exhibit either paramagnetic or diamagnetic properties by changing the temperature conditions under which it solidifies and crystallizes.

A Repetition of Wheatstone's Experiment of 1834: Francis E. Nipher, Washington University, St. Louis.

The paper gave reproductions of Wheatstone's figures in *Phil. Trans.,* 1834. It was pointed out that it seemed somewhat improbable that his mirror could have been given a velocity of 800 revolutions per second. The three sparks in a line half a mile in length were photographed. When Wheatstone's connections were used his result was not obtained. When one end of the line was grounded, the sparks always began at the gap nearest to the terminal of the machine and the others followed in consecutive order in time. The result was the same for the positive as for the negative discharge. With Wheatstone's connection the middle spark should appear last, but the result was so affected by distributed capacity that his result was not attained.

Determination of the Susceptibility of Copper and Tin and their Alloys: O. C. Clifford, University of Chicago.

By means of a torsion balance, hung symmetrically with respect to two magnetic poles and made diamagnetic by superposition of bismuth pieces, the variation of the force of repulsion upon the test pieces examined was measured. From the mechanical force thus determined and the constants of the magnetic field found with an exploration coil, the susceptibility of the specimens was obtained. Within a range of field strengths of from 200 to 600 lines, the bismuth gave the same susceptibility as had been found by other observers with much larger fields. By careful preparation tin was obtained which had a susceptibility of $+.31 \times 10^{-6}$. A very pure specimen of native copper was found to have a susceptibility of -1.22×10^{-6}. Alloys made from this tin and copper had susceptibilities which were in some cases of higher negative value than that of the copper, thus showing in diamagnetism a phenomenon altogether analogous to the Heusler phenomenon in paramagnetism. As the per cent. of tin increased from zero

to about that used in speculum metal, the diamagnetism increased to a maximum and then decreased, making the susceptibility of the alloy a complex function of the per cent. of tin and copper present. The maximum diamagnetic susceptibility of the alloys was about -2.1×10^{-6}.

A Satisfactory Form of High Resistance: G. W. STEWART, University of North Dakota.

There is an increasing demand for a satisfactory form of very high resistance. This paper makes record of a very convenient and satisfactory form of high resistance in which carbon is utilized, and also furnishes data concerning its constancy. Commercial lampblack mixed with a lacquer, "zapon L," is spread into films upon an insulating base. These films are permanent, are not subject to ordinary changes in temperature, do not evaporate, and do not crack. Such films are very easy to make, and can be given practically any range. The resistance temperature coefficient of such films when hard rubber is used as a base, is from 0.1 to 0.2 per cent.

Phonographic Record of the Doppler Effect: CHAS. T. KNIPP, University of Illinois.

In this paper an attempt was made to obtain a phonographic record of the Doppler effect. The phonograph was placed at the side of the track, and distant about thirty feet. The horn was directed toward the moving source of sound. A record was taken of a continuous blast of the locomotive whistle sounded over a distance of about 1,000 feet—500 feet on either side of the position of the observer. By simple calculation it can be shown that the pitch will be lowered one tone when the train velocity is 44 miles per hour or 64 feet per second. The train in question was moving at a velocity of 57 miles per hour or 84 feet per second. The pitch accordingly should be lowered 9.3/8 tones. The phonographic record when reproduced showed a distinct lowering of the pitch—fully a tone as far as it was possible to judge by the ear.

How does the Violinist control the Loudness of his Tone: HARVEY N. DAVIS, Harvard University.

One conclusion of the Helmholtz theory of the motion of a violin string does not seem to agree with experience, viz., that if the bowing point is fixed, the loudness of the tone depends wholly upon the speed of the bow and not at all upon its pressure. In explanation of this discrepancy, it is found that a certain pressure corresponds to each bowing speed, and that below this pressure the Helmholtz form of vibration can not be maintained.

The author is led to believe that the actual motion of a violin string is not usually of the normal Helmholtz type, but of the sort described in his paper a year ago as corresponding to light bowing. With the special apparatus devised it is possible to reduce the energy of the vibration to barely half its normal value, and the author hopes to be able to determine the limits of the sub-critical region for an actual violin and compare with them observations already obtained of the pressures ordinarily used.

A Wave Machine showing Damped or Undamped Compound Waves: ALBERT B. PORTER. (Read by title.)

This machine compounds two harmonic waves either or both of which may be of constant amplitude, may have any desired damping coefficient, or may increase in amplitude at any desired rate. It thus serves not only to illustrate the ordinary problems in simple harmonic motion, but also the effects of damping by frictional or

other resistance, and the phenomena of resonance.

The machine offers nine choices of ratio of periods between the two simple waves, and each of these ratios may be thrown slightly "out of tune" for the purpose of showing beats, or the changes in the compound wave and the evolutions of the Lissajous figure as the phase progressively changes. There are three choices of wavelength of the fundamental wave. The amplitude of either wave may be given any value between zero and the maximum permitted by the size of the machine; the phase difference can be varied between 0° and 360°; and either wave may be given any desired positive or negative damping coefficient.

Notes on Harmonic Analysis: Albert B. Porter. (Read by title.)

This paper describes: (1) A geometrical representation of the Fourier coefficients of a periodic function as a series of solids; (2) the essential mechanism of an integrating harmonic analyzer which is based on this representation; (3) a new method of harmonic analysis by use of specially ruled sine-coordinate paper, on which the given function is plotted, and the Fourier coefficients are determined by measurement with an ordinary planimeter, and (4) a modified form of the Yule analyzer.

Some Experiments on the Radioactivity of Potassium Salts: J. C. McLennan, University of Toronto.

In this paper an account is given of some experiments which confirm the discovery by Campbell and Wood that potassium salts emit a radiation of high penetrating power.

In the first series of measurements some chemically pure potassium sulphate was spread into a thin layer and placed close to and beneath an ionizing chamber 40 cm. long, 26 cm. wide and 28 cm. high. The bottom of this vessel was closed with a fine-meshed gauze which permitted the radiation to pass through. The saturation currents were measured with a quadrant electrometer.

In the first set of measurements different areas of the salt were exposed, and it was found that the radiation emitted was directly proportional to the free surface of the salt.

In a second series of measurements a layer of the salt 35 cm. by 18 cm. was placed under the ionizing chamber, and then gradually lowered, thus altering the air column traversed by the radiation before it entered the chamber. The results of this experiment show that it was necessary to lower the layer of salt some 17.5 cm. before the saturation current was reduced one half. With the salt at a distance of 42 cm. from the chamber, the ionization current was still approximately considerable, being one tenth of its highest value. In a third series of measurements a layer of the salt was again placed beneath the ionization chamber, and the absorption of its radiation studied by covering it successively with an increasing number of sheets of tin-foil, and at the same time measuring the corresponding saturation currents. The tin-foil used in these measurements was .0089 mm. in thickness. It was found that the saturation current diminished from 188 to 10 units as the number of sheets of tin-foil were increased from 0 to 32. Seven sheets reduced it to one half its value.

The fourth series of measurements was made with the object of ascertaining whether this radiation from potassium salts, which from its characteristics evidently consisted of β or γ rays, was due to some property possessed by the salt intrinsically, or whether it was due to a secondary radiation excited in the salt by the penetrating rays from the earth.

From the experiments described it is clear that the effects produced were due to a primary activity possessed by the salt and not due to a secondary activity imparted to it.

On Variations in the Penetrating Radiation from the Earth: C. S. WRIGHT, University of Toronto. (Communicated by Professor J. C. McLennan.)

In this paper the author gives an account of some measurements made on the penetrating radiation from the earth in different localities on the north and south shores of Lake Ontario, and also at different points on the surface of the lake during the passage over it by steamer.

In making these measurements observations were taken by means of an electroscope of the improved Wilson type on the saturation current through the air in a closed lead cylinder.

The following statement contains a summary of the results. In this table the conductivities are corrected for variations in temperature and pressure, and are expressed for purposes of comparison by the number of ions generated per c.c. per second within the cylinder at the different points of observation.

TABLE OF CONDUCTIVITIES

Observation Stations	No. of ions generated per c.c. per second within the lead cylinder
First Set of Observations	
Physical Laboratory, University of Toronto	22.5
At edge of harbor waters (30 meters from shore) (filled-in ground)	19.3
South end of breakwater at Eastern Gap (water 4 meters deep)	14.1
On sand spit between lake and harbor (110 meters from shore)	14.26
On ground floor Canoe Club, at end of pier in harbor (water under floor 6.5 meters deep)	13.5
Second Set of Observations	
Old Physics Building, University of Toronto	23
New Physics Building	22
On board steamer *Corona* at dock	18
At different points between Toronto Harbor and Niagara River bell buoy	18.9, 18.8, 19.1, 18.3 (av. 18.8)
At Niagara dock	20
Niagara River, Paradise Grove	18.2
Queenston Heights	23.3
Niagara Falls Park	22.9
Elevator Shaft, Ontario Power Co., Niagara Falls (40 meters under ground)	22.6
At foot of Niagara Falls	20.3

A Null-reading Instrument for the Measurement of Ionization: S. J. ALLEN, University of Cincinnati.

A Comparison of the Formulas of Helmholtz and of Nernst for the E.M.F. of Concentration Cells: H. S. CARHART, University of Michigan.

The Stability of Cadmium Cells: H. S. CARHART, University of Michigan.

On the Separation of Echelon Spectra by Gratings: A. A. MICHELSON, University of Chicago.

Selective Reflection as a Function of the Atomic Weight of the Base: W. W. COBLENTZ, Bureau of Standards, Washington. (Read by title.)

The Infra-red Absorption of Certain Biaxial Crystals for the Three Principal Directions of Vibration: R. E. NYSWANDER, Cornell University.

New Physical Aids to Navigation: H. E. WETHERILL, Philadelphia. (Read by title.)

The Distribution of Energy in the Spectrum of the Tungsten Filament: R. E. NYSWANDER, Cornell University. (Read by title.)

The Use of Complex Quantities in Alternating Currents: G. W. Patterson, University of Michigan.

Physical Research at a Mountain Observatory: G. E. Hale, Mt. Wilson Observatory.

Some Curious High-temperature Phenomena: C. E. Mendenhall, University of Wisconsin.

Alfred D. Cole,
Secretary

Vassar College

SCIENTIFIC BOOKS

The Origin of a Land Flora: A Theory based upon the Facts of Alternation. By F. O. Bower, Sc.D., F.R.S., Regius Professor of Botany in the University of Glasgow. With numerous illustrations. 8vo, pp. xii + 727. Macmillan and Company, Limited. St. Martin's Street, London, 1908.

The author of this book is well known to American botanists as the writer of many lucid articles, and especially as the propounder of a very helpful theory as to the nature of the flower and its relation to the remainder of the sporophyte. When Professor Bower published his "theory of the strobilus" (*Annals of Botany,* Vol. VIII., 1894, p. 343) he made a contribution to morphology which at once marshaled the floral and foliage structures of higher plants in accordance with the doctrine of evolution, and destroyed the time-honored theory of the metamorphosis of foliage leaves into the perianth and essential organs of the flower. In the light of this theory the origin of the flower is no longer the hazy, although plausible impossibility of the older text-books. That he swept away along with much accompanying rubbish, and in its place gave us an explanation which has the double merit of agreeing with observed facts, as well as being biologically possible. Now the author who gave us a rational theory of the origin of the flower appears with a volume devoted to the origin of the terrestrial habit in plants, or as he puts it in the title of his book—the origin of a land flora—and we may predict for this later theory a history equally successful with the former.

The volume consists of forty-seven chapters, divided into three parts, the first (of twenty chapters) being devoted to a "statement of the working hypothesis," the second (of twenty chapters, also) including a "detailed statement of facts," and the third (of seven chapters) devoted to "conclusions." Starting with the accepted doctrine of biologists that animal and plant life originated in the water, he shows that it is the sporophyte generation which becomes terrestrial, while the gametophyte is wholly aquatic, or at best still greatly dependent upon an abundant supply of water. His statement (p. 244) is so clear that we quote it here verbatim: "In respect to their whole life-cycle the *Archegoniatae* may be said to show an amphibial existence, the aquatic and the terrestrial characters being reflected in its two alternating phases. The gametophyte is as a rule delicate in texture, without intercellular spaces in its tissues, or a fully developed water-conducting system, while its sexual organs only become functional on their rupture in water outside the plant-body: the gametophyte thus proclaims its ultimate dependence on external fluid water as thoroughly as an alga. The sporophyte, on the other hand, is a characteristically subaerial body; this is shown by its more robust habit, its effective ventilating system, and its vascular strands for the conducting function seen in the higher forms: its final result, the maturing and dissemination of spores, is normally carried out under circumstances of dryness. All these features mark it as an essentially terrestrial phase."

In Chapter V. the author discusses the cytological differences between the gametophyte and sporophyte first distinctly pointed out by Strasburger in 1894, accepting chromosome-reduction as marking the end of the sporophyte generation and the beginning of the gametophyte, and chromosome-doubling as the end of the gametophyte generation and beginning of the sporophyte. By applying this test the beginnings of an alternation of generations may be recognized cytologically in the